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Energy saving and emission reduction revolutionizing China's environmental protection

Qiang Wang [a,b,c,*], Yong Chen [b]

[a] Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
[b] Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou 510640, China
[c] Graduate University of Chinese Academy of Sciences, Beijing 100049, China

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ABSTRACT

Great pressure to curb carbon emission and increased need for energy have forced China to develop an "energy saving and emission reduction" (ESER) plan. ESER has become China's basic national policy, and a guideline for China's energy and environmental issues during the 11th Five-Years Plan (2006–2010). ESER represents a recalibration of China's economic model, moving away from growth-at-all-cost in favor of a more "balanced and sustainable" output. In 2007, China's GDP grew by 11.4%, but emission of COD and SO_2 decreased by 3.14% and 4.66% respectively compared to 2006, energy consumption for each unit of GDP declined by 3.27% also compared to 2006. ESER is also the engine behind reform of China's traditional administrative system which has always favored economic growth over environmental protection. The ESER accountability system sets green efforts as a decisive factor in determining the career prospects of local leaders. Also, China's State Environmental Protection Agency has been upgraded to the Ministry of Environmental Protection, gaining cabinet status for the first time. A greener future relative to the previous three decades can be anticipated with confidence for China provided that the best practices enunciated by ESER are taken to heart by policymakers.

Contents

1. Introduction

No country in the history of mankind has emerged as a major industrial power without substantial use of fossil energy and concomitant environmental damage. Just as speed and scale of China's rise as an economic power are unprecedented in history, its energy demand and pollution problems have also shattered all

* Correspondence address: Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, 511 Kehua Street, Guangzhou 510640, China.
E-mail address: tswangqiang@yahoo.com.cn (Q. Wang).

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precedents. The large population and high speed of economic development have led to a large increase in energy demand and have been primary drivers of the recent acceleration in global carbon emissions [1]. The conflict between booming economic growth and energy demand, versus environmental protection challenges China's future development and energy supply as well as its environment. Although specific solutions to many specific environmental problems have been proposed, a key unanswered question is how to decouple economic growth and energy use from environmental degradation. One answer is the "energy saving and emission reduction" (ESER) plan.

Energy saving and emission reduction (in Chinese name, Jie Neng Jian Pai) has been set as guideline for environmental issues in the 11th Five-Years Plan (2006–2010) [2], the primary state fundamental policy [3,4], and as focus for China's 2007 macro-control policy [5]. China has set targets to reduce energy consumption by 20% for every 10,000 Yuan (1466 U.S. dollars) of GDP in the 11th Five-Year Plan period, and reduce pollutant discharge by 10% [2].

2. Increasing energy demand and carbon emission driven ESER become China's national policy

2.1. Increasing energy demand

Since the late 1970s, the Chinese government has reformed the economy from a Soviet-type centrally planned economy to a more market-oriented one (The Socialist Market Economy) with a rapidly growing private sector. Since its introduction, China has been the fastest-growing major nation for the last three decades with an average annual GDP (gross domestic production) growth rate of nearly 9.8% [6]. The thrust behind China's rapid economic growth is provided by large injections of energy, derived primarily from coal (nearly 70% of the total energy consumption) [7]. The total energy consumption of China increased about 465% from 1978 to 2007 [6] (see Fig. 1).

Currently, China is the second energy producer and consumer after the United States in the world [8], and will overtake the United States to become the world's largest energy consumer soon after 2010 [9]. Economic growth is projected to continue at higher than 7% per year; at this rate, GDP will quadruple in 20 years [10]. To fuel its economic growth, China's primary energy demand is projected to more than double from 2005 to 2030 [11] (see Fig. 2).

However, in terms of coal, oil and natural gas reserves, China ranks 3rd, 13th and 17th in the world respectively. Moreover, per capita coal, oil and natural gas reserves in China are only 79%, 6.5% and 6.1% of the world's average [12]. Meanwhile, the per-capita average of arable land is less than 30% of the world's average, which has hindered the development of biomass energy [13]. In the first half of 2007, China became from a net coal exporter to a net coal importer. China's net coal import is projected to reach 3% of its

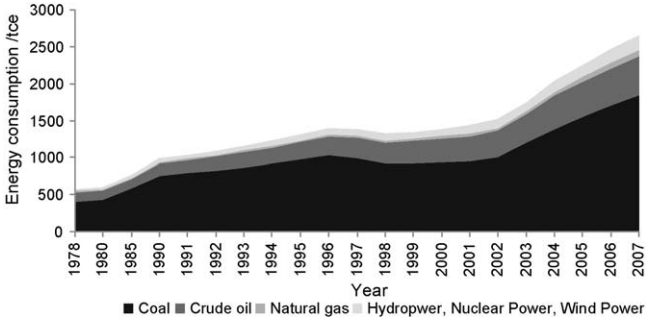

Fig. 1. Energy consumption growth and structure in China from 1978 to 2007 [6].

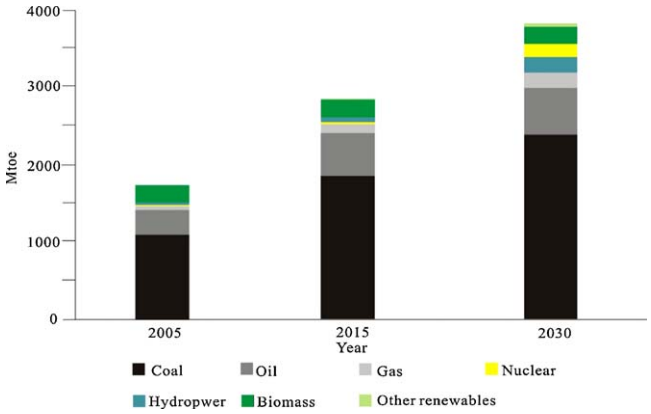

Fig. 2. China's primary energy demand [11].

demand and 7% of global coal trade in 2030 [9]. As far as oil, China surpassed Japan to become the second-largest oil importer in 2005. Currently, nearly half of China's oil consumption needs are imported [14]. It is projected that China's net oil imports will jump from 3.5 mb/d in 2006 to 13.1 mb/d in 2030 [11].

In 2006, per capita energy supply in China was 1.43 TOE (ton of oil equivalent) [15], whereas per capita energy supply in U.S. and OECD (Organization for Economic Co-operation and Development) is 7.74 TOE and 4.70 TOE respectively [16]. With four times as many people as the United States, China cannot duplicate the energy-intensive Western model because of resource limitations. Although advanced renewable and sustainable energy resources form the ideal solution, the renewable and sustainable energy is projected to account for only 15% of total energy consumption by 2020 [17]. So the most effective short-term strategy is energy conservation and efficiency.

2.2. Environmental pressure

Coal accounts for nearly 70% of China's energy use (see Fig. 1) [7], compared to 24% for the world average [18]. Already, China uses more coal than the United States, the European Union and Japan combined [19]. However, burning coal is the principal agent responsible for air pollution, water shortages, polluted soil, ecosystem degradation, and widespread human illness [12,20]. Air pollution from coal has become so bad in China that chronic respiratory disease has become a leading cause of death. Water shortages have become regular in many China's regions as for every ton of coal produced two-and-a-half tons of water become polluted. Acid rain as a result of excessive coal production is almost constant in one third of China's territory [20].

Of course the biggest problem of them all, is climate change (see Fig. 3). In 2005, coal accounted for 42% of global CO_2 emissions. In that year, coal combustion accounted for 82% of China's CO_2 emissions [21,22]. China is by far the biggest contributor to incremental emissions, overtaking the United States as the world's

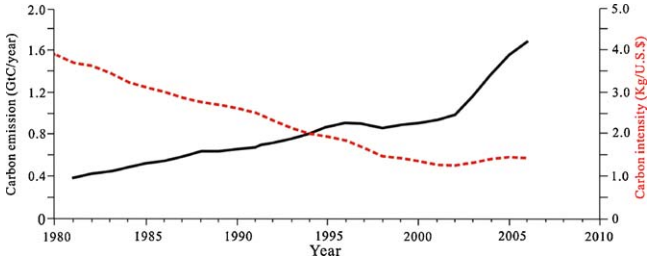

Fig. 3. CO_2 emissions and carbon intensity for China from 1980 to 2006 [24].

biggest emitter in 2006 [23], where coal-burning holds dominant place [11]. In a hypothetical scenario where carbon intensity keeps pace with a GDP growth rate of 7%, China would be emitting by 2030 as much as the whole world does currently (8 GtC/year) [24].

However, China will be one of the worst-impacted regions in the world if climate changes as predicted [24–26]. For example, global warming is projected to reduce China's agricultural by 5–10% by 2030 [26], thus adding stress to a country that has 20% of the world's population and only 7% of its arable land. In addition, three main industrial centers of China are on lowland areas: the Gulf of Bohai region with the Beijing–Tianjin axis, the Yangtze River delta radiating inland from Shanghai, and the Pearl River delta encompassing Hong Kong and Guangzhou. A sea level rise of one meter would inundate 92,000 km^2 of land in these three regions [24,26].

Energy efficiency is a good way for curbing CO_2 emission. Indeed, improving energy efficiency has driven the large decrease in China's carbon intensity (carbon emission per unit of GDP) [24] (see Fig. 3). China's CO_2 emission has increased by only 5.4% per year [27,28] by emphasizing energy efficiency, while its GDP has grown by almost 10% per year over the last nearly three decades [6].

Great pressure to curb carbon emission and increasing energy need have forced China to develop its "energy saving and emission reduction" (ESER) plan.

3. ESER promotes decoupling between economic growth and energy use, versus environmental damage

Energy saving and emission reduction is focused on decoupling China's economic growth and energy use from environmental damage. ESER has recalibrated China's economic model away from growth-at-all-costs in favor of a more balanced and sustainable output, and triggered the reform of traditional administrative system which favored economic growth over environmental protection.

3.1. Changing the economic development model

Rapid growth in GDP has been China's main goal during the past decades. The dominant development model caused inefficient resource use and high pollution to achieve a high GDP. For example, governmental statistics show that from 2003 to 2004, the average growth rate of China's energy consumption was six percentage points higher than the country's economic growth rate [7]. China brings two additional coal-fired power plants to the electric power grid every week [29] to fuel its economic growth. However, China's traditional economic development model has been revised by ESER.

3.1.1. Shutting down backward production capacity

For almost three decades, China's government welcomed backward producers to settle there for GDP growth**.** Churning out iron, steel, cement, electrolytic aluminum, calcium carbide, coke, iron alloy and other products, manufacture helped to make China into one of the world's fastest GDP growers. In recent times though, a series of radical proclamations that sent shudders though the business community, China declared that it will close down any business that fails to comply with the energy saving and pollution control standards enunciated by ESER.

In 2007, small thermal power plants with a total capacity of 14.38 million kilowatts, 2322 small coalmines, backward iron foundries with a total capacity of 46.59 million tons, backward steel mills with a total capacity of 37.47 million tons and backward cement plants with a combined capacity of 52 million tons were put out of business [30]. Moreover, by 2010, small coal-fired power plants with total electricity generating capacity of 50 million kilowatts, backward cement plants with a total capacity of 250 million tons, backward steel mills with a total capacity of 100 million tons and backward iron foundries with a total capacity of 55 million tons will be closed down (see Table 1), according to *General Work Plan for ESER*.

Table 1
A closure list of backward production capacity targets [3].

Project	2007 targets	2010 targets
Solid fuel-burning electricity	10 million kilowatts	50 million kilowatts
Iron	30 million tons	100 million tons
Steel	35 million tons	55 million ton
Electrolytic aluminum	100,000 tons	650,000 tons
Iron alloy	1.2 million tons	4 million tons
Calcium carbide	500,000 tons	2 million tons
Coke	10 million tons	80 million tons
Cement	50 million tons	250 million tons
Glass	6 million weight boxes	30 million weight boxes
Papermaking	2.3 million tons	6.5 million tons
Alcohol	400,000 tons	1.6 million tons
Monosodium glutamate	50,000 tons	200,000 tons
Citric acid	20,000 tons	80,000 tons

3.1.2. Improving energy efficiency

China's spending on energy efficiency is unequivocal. After a total of 23.5 billion Yuan (3.44 billion U.S. dollars) has been earmarked for the effort in 2007, China's central government planned to increase spending on the ESER scheme by 78%, to 41.8 billion Yuan (6.13 billion U.S. dollars) in 2008 [31]. The energy efficiency budget of the Ministry of Finance is only part of China's effort and financial spending for environmental purposes. Regional governments also direct budgets to similar uses.

The budget by the Ministry of Finance has been used to support ambitious plans that include the so-called "top-10 national energy conservation projects" (see Table 2). Though only termed "projects," each will have an environmental impact so important that it may have national significance. The adoption of regional combined circular power plants (CCPP) technology, for example, is expected to save 35 million TCE (tons of standard coal equivalent) in five years. An improvement of 5 percentage points in existing industrial boiler energy efficiency can result in a further cut of 25 million TCE in five years. If the energy efficiency of all kilns can be raised by 2 percentage points, another 10 million TCE will be cut in five years. Through saving petroleum and seeking substitutes, such as by developing ethanol, China can save an accumulative 38 million tons of oil by 2010. And the country's new buildings for both private and public use are required to save 50% of energy compared to the level of energy consumption in the 1980s by adopting green technology and materials, which can conserve at least 100 million TCE in five years. The 10 projects cover not just

Table 2
Top-10 national energy conservation projects [32].

	Project
1	Improving coal-burning industrial boilers and raising their energy efficiency
2	Developing regional combined circular power plants (CCPP)
3	Recycling waste heat and pressure
4	Reducing the use of petroleum and seeking substitutes
5	Increasing energy efficiency in power generation systems
6	Improving overall performance of energy systems
7	Energy conservation in construction
8	Lighting systems
9	Government leadership in conservation
10	Strengthening monitoring systems and related services in energy saving and emission controls

industrial but also domestic consumption. Advocacy of green lighting systems is directed toward Chinese families. The nation plans to push forward the use of highly energy-efficient bulbs at home and in public infrastructure, which could save about 29 billion kWh of electricity. Economic planners estimate that the top-10 national projects will save 240 million tons of TCE in five years [32].

3.1.3. Upgrading economic growth model

Export, investment, and consumption are known as the troika of China's economic growth. According to the magnitude of their different contribution to economic growth, export and investment are more important than consumption [6].

Administrative approval to investment energy intensive or highly polluting was restricted. The excessively fast growth of electricity, steel, nonferrous metals, construction materials, oil processing and chemical industries in the first quarter 2007 is blamed for the difficulties in fulfilling the ESER's goal [3]. Accordingly, the government has not approved any new projects that fail to pass the government's energy saving and environmental impact assessment [33].

Meanwhile, in a move to increase energy utilization efficiency and strengthen environmental protection, China announced in September 2006 that tax rebates for certain export products with low value-added, high pollution, high energy consumption and resource consumption will be abolished or reduced [34]. And the government declared again on 19 June 2007 a major downward adjustments to export Value-Added Tax (VAT) refund rates [35]. The announcement makes clear that the reductions of refund rates, and even the complete elimination of the export VAT refund in some cases, will apply to a broad range of products that are "high pollution", "high energy and resource consumption".

In 2007, China's economy expanded at its fastest pace in 13 years, with 11.4% annual increase in GDP. However, energy consumption per unit of GDP fell by 3.27% in 2007, a significantly better achievement than that of the year before. Water consumption per 10,000 Yuan of added value of industry dropped by 9.5%. For the first time in recent years, sulfur dioxide emissions and chemical oxygen demand both decreased, with SO_2 dropping by 4.66% and chemical oxygen demand by 3.14% [6].

3.2. Reforming the administrative system

China's traditional administrative system favored economic growth over environmental protection. Reform of its traditional administrative system has been triggered by ESER.

3.2.1. Changing evaluation system

Economic performance, especially GDP growth had been China's main or sole criterion for selecting and promoting government leaders before the arrival of ESER. GDP growth has been the ruling local government's "top priority". Local leaders put economic growth ahead of any concern about the environment. The cadres showered local businesses with perks. Sometimes, for the sake of their own political scorecards, local officials joined forces with businesses seeking windfall profits at the expense of the environment. As a result, although more than 100 environmental laws and regulations exist in China, they are often ignored by companies. However, such situation has been changed because the old evaluating system is overthrown by ESER.

In May 2007, China's State Council published a *General Work Plan for Energy Conservation and Emission Reduction* [3] (see Table 3). In June 2007, a General Working Group for ESER, a new, high-level, authoritative national organization that coordinates all relevant ministries and agencies for economic development and environmental protection, was established with Premier Wen Jiabao as group leader [4]. An energy-saving evaluation system that relates energy efficiency to the appraisal of local officials' performance was adopted. Energy efficiency and pollutant discharge reduction was set as key factor for assessing economic and social development in all localities as well as the performance of government and company leaders. Moreover, an ESER accountability system was adopted. Local leaders risk losing promotion opportunities or even jobs if they fail to meet ESER's targets [4,36]. The accountability system has set green efforts as a decisive factor in determining the career prospects of local leaders since June 2007.

The accountability system, along with practices in measuring and monitoring the use of energy and emission, has driven the decline in China's energy use—from 2.78% in the first half of 2007 to 3% in the first three quarters to 3.27% for the whole year, in contrast to the 1.33% decline for the whole of 2006 [37].

3.2.2. Consolidating environmental protection agency

China's State Environmental Protection Agency (SEPA), a vice-ministerial body, is responsible for the environment issues. SEPA lacks the power to shut down polluters. To understand how bureaucrats and business leaders flout SEPA, one might consider taking a trip to Lake Taihu, China's third largest and the source of drinking water to 5.8 million residents of the city of Wuxi. In the 1990s, as industry sprang up on the lakeshore and Taihu grew more polluted, SEPA ordered local factories to clean up their wastewater. Then in 1999, local officials said the problem had been solved as factories installed treatment plants. But those new facilities often stayed idle as companies refused to shoulder the cost of operating them, and factories continued to dump untreated waste into the lake. The water in the areas bordering Lake Taihu was heavily polluted [38]. What is worse, when environmental disasters occur, environmental protection agencies often bear the blame. For example, after the chemical spill in the Songhua River in 2005, the director of SEPA was dismissed [39].

Table 3
Major energy efficiency/pollution control targets of the *General Work Plan for Energy Conservation and Emission Reduction* for the year 2010 [3].

Project	Target
Energy consumption	Energy consumption per 10,000 Yuan of gross domestic product reduced from 1.22 tons of standard coal in 2005 to below 1 ton, down by about 20%
Water consumption	Water consumption per unit of industrial value added reduced by 30%
Major pollutants	Discharge of major pollutants reduced by 10%
Sulfur dioxide	Discharge of sulfur dioxide reduced from 25.49 million tons in 2005 to 22.95 million tons
Chemical oxygen demand	Chemical oxygen demand (COD) reduced from 14.14 million tons in 2005 to 12.73 million tons
Urban treated sewage	The ratio of national urban treated sewage reaching at least 70%
Industrial solid wastes	The ratio of comprehensive utilization of industrial solid wastes reaching 60% or more
Urban sewage treatment	Daily urban sewage treatment capacity increased by 45 million tons
Recycled water utilization	Daily recycled water utilization capacity increased by 6.8 million tons
Capacity to reduce COD	Capacity to reduce chemical oxygen demand (COD) increased by 3 million tons
Desulfurization units	Putting into operation desulfurization units with a combined capacity of 355 million kilowatts
Coal gangue-fueled power plants	Building coal gangue-fueled power plants with a combined generating capacity of 20 million kilowatts

However, SEPA has been authorized in ESER enough power to deal with issues related to pollution control and discharge reduction. For example, a "green-credit policy", which required SEPA to hand over lists of companies of "high energy consumption" and "high pollution" to the central bank and the regulatory commission, was put in place to determine access of polluting enterprises to bank loans in view of their environmental performance. Some companies have already found themselves unable to obtain loans [40]. With the cooperation of the Ministry of Commerce, SEPA is strengthening its supervision over Chinese exporters, ban exporting at the expense of environmental pollution and extensive energy consumption, and withdraw export permits for companies that do not meet environmental standards [41].

A "green securities" plan was launched in February this year. The new requirements impose barriers on heavy polluters applying for an initial public offering (IPO), for refinancing on domestic stock, and mandating that listed companies disclose more information about their environmental performance [42]. Of course, water environmental protection in Taihu Lake has changed radically. By the end of September 2007, more than 1340 polluting factories has been closed or given directives to close. And the rest are ordered to clean up or be permanently shut down [43]. On March 2008, SEPA has been promoted to the Ministry of Environmental Protection, gaining cabinet status for the first time [44].

4. Outlook and conclusion

Modernizing China's economy requires further industrialization and urbanization. These two processes are inevitable, but neither can occur without a commensurate increase in energy consumption and pollutant abatement. However, China's extensive economic growth has gone beyond the bearing ability of environment and resources. China is left with no other alternatives but to decouple energy use and economic development from environmental degradation. Given the social and political complexity between economic development and environmental protection, there will be no easy. But the effect of energy saving and emission reduction show that there is hope. Two experiences of ESER may be valuable to policymakers in designing future policy: First, energy conservation and efficiency and environmental protection should be treated as an integral part of sustainable economic development. Second, establishing a new, high-level, authoritative national organization that coordinates all relevant ministries and agencies for economic development and environmental protection can effectively improve energy efficiency and environmental protection.

In all, China has the resources to decouple energy use, environmental degradation and economic development. One can be confident that it can create a lot greener China than the one prevailing the previous three decades provided that best practices of ESER are taken to heart by policymakers.

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